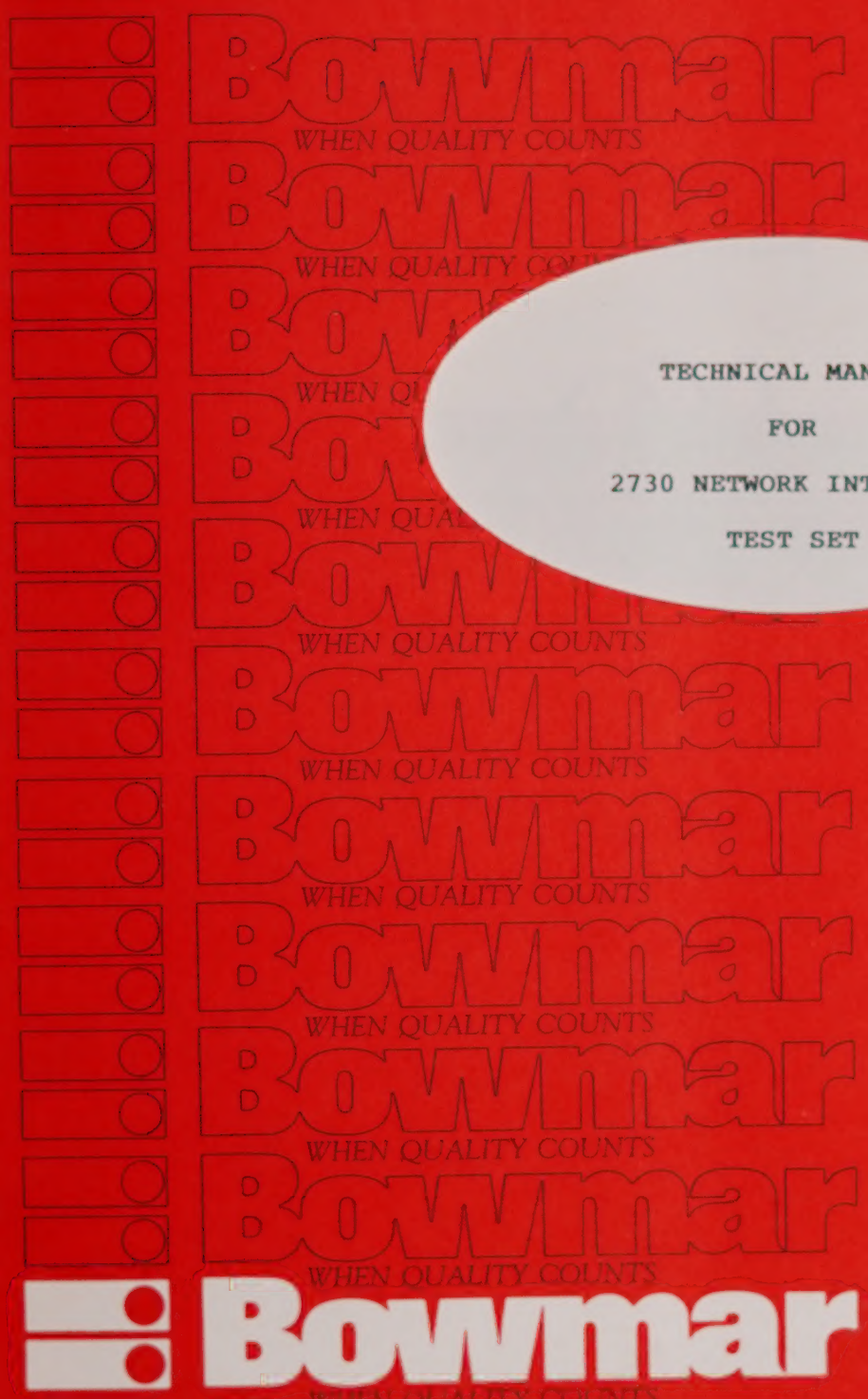
TECHNICAL MANUAL

FOR

2730 NETWORK INTERFACE

TEST SET



Bowmar

Communications Test Equipment

Bowmar/ALI Inc.
531 Main Street
Acton, Mass. 01720

TECHNICAL MANUAL

FOR

2730 NETWORK INTERFACE

TEST SET

MANUFACTURED BY:

BOWMAR/ALI, INC.
531 Main Street
Acton, MA 01720

REVISION C
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Bowmar/ALI, Incorporated

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2730 NETWORK INTERFACE
TEST SET

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1.0 INTRODUCTION

1.1 Equipment Description

The Model 2730 provides an interface for the T1 Line at the NI (Network Interface). Working in conjunction with the Model 273 Transmission Test Set, it enables comprehensive testing of the T1 lines to assure performance within tariffed specifications for HCDS service.

Packaged as a cover option for the Model 273 Transmission Test Set, the Model 2730 increases the utility of the Model 273 by enabling it to terminate T1 Carrier lines (1.544 Mbs) at the Network Interface (NI) in place of the customer furnished Channel Service Unit (CSU). The Model 2730 measures Repeater Loop Current, Level Measurement at 772 kHz and, connected to the "ERRORS" output of the 273, displays individual errors measured by the 273, while the 273 displays "ERROR SECONDS" detected on the T1 1.544 Mbs data stream. A selection of 100 coded patterns enables the 2730 to loopback and restore CSU's (both plain and addressable) and provide Stress Patterns for "SPAN LINE" testing.

MODEL 2730 AND MODEL 273 COMBINED FEATURES

*Span Line Repeater Power Loop Current Measurements

*Level Measurements at 772 kHz - expressed in dBm's

*Provides In-Band "1 0 0 0 0" Loopback and "1 0 0" Release Patterns per PUB 54015

*Provides Stress Patterns for Span Lines and Underseas Cable System Testing

*Simulation of a CSU

*Simultaneous Measurement/Display of Individual Errors and Error Free Seconds at the Network Interface

The Model 2730 T1 Network Interface Device is packaged as a cover option for the Model 273 Transmission Test Set. Powered from 117 vac 50/60 Hz it may be operated as an independent test set

for basic line termination and 772 kHz level measurements at the Network Interface. Working in conjunction with the Model 273 Transmission Test set, it may be used either at the Central Office or at the Network Interface to perform the series of tests necessary to validate the performance of T1 span lines installed for High Capacity Digital Service (HCDS).

At the Network Interface, the Model 2730 terminates the T1 line with centertapped send and receive transformers. The transformer centertaps provide simplex dc power loop feed simulating that of a typical CSU. Included, is a means of measuring the loop current to ensure adequate powering of the repeater span in both old and new installations.

Operating in conjunction with a Model 273 as a source of an all ones pattern at the send source, the Model 2730 may be used to measure the signal level around 772 kHz at the NI or elsewhere in the span.

With the Model 2730 terminating the line and the Model 273 operating in the APS mode, the combination performs the functions of a CSU, regenerating the signals from the receive line for application to the send line for loopback tests with the CO (Central Office).

For error testing, the ALBO, (Automatic Line Build Out) capability of the Model 273 enables Bit Error Measurements by direct connection to the receive line at the NI. Results may be displayed on the Model 273 as a count of individual errors or error seconds. Individual errors and error seconds counts may be displayed simultaneously using the counter of the Model 2730 to display individual errors from the Errors Output of the Model 273 while error seconds are displayed on the Model 273.

The Model 2730 includes the capability of sending both *addressable and non-addressable in-band "1 0 0 0 0" patterns to loopback a distant end CSU and a "1 0 0" pattern to release the loopback. The Model 2730 also includes pushwheel selection of a series of pre-selected patterns for stress testing an operating span line or underseas cable.

*The customer must furnish Bowmar/ALI with the addressable codes. Patterns may be up to 16 bits wide at each address.

1.2 Scope of Manual

This manual contains descriptive details of the Model 2730 plus related applications notes, diagrams, maintenance and parts information. The descriptive details are reduced to the categories of physical and functional specifications, operating procedures and operating principles. The manual's purpose is to provide the user with sufficient information to enable effective use and proper maintenance of the 2730.

1.3 Specification Summary

LEVEL MEASUREMENTS:

Range: -40 to +20 dBm via a filter centered 772 kHz.

0 dBm = 1 mW into 100 ohms = .316 Vrms

Accuracy: ± 1 dB

Display: Three digit decimal display -40.0 to +20.0 dBm

LOOP CURRENT MEASUREMENT:

Display: Three digit decimal display, 30 to 200 mA

Accuracy: ± 10%

Impedance: 150 ohm

ERROR COUNTER:

Display: Six digit range 00 to 999999 with reset

Input: TTL Levels from "ERRORS" output (BNC connector) 273

WORD GENERATOR:

Address Range: 00 thru 99 up-down selectable switch

Address Codes: 1 0 0 0 0
1 0 0

PROM Driven via programable EPROM on plug-in program module

Momentary toggle switch to transmit selected word in place of QRSS Data for 5 seconds

LINE INTERFACE IMPEDANCE:	RCV: 10K ohm - Bridge 100 ohm - Term. SEND: 100 ohm
MODEL 273 INTERFACE IMPEDANCE	INPUT: 10K Ohm - Bridge 100 Ohm - Term. OUTPUT: 100 Ohm
LINE SEND TRANSMITTER:	Level: $\pm$ 3V $\pm$ 10% (open circuit)
POWER:	117V AC $\pm$ 10% 50/60 Hz self contained Power Supply
HOUSING:	The 2730 mounts in place of the standard cover furnished with the 273 Test Set. Housed in the cover are the electrical accessories to provide for: a. T1 Level measurements b. T1 Errors count driven from the 273 c. A T1 coded word generator Space is provided to house the accessory patch cords for interconnection with the associated 273 equipment.

1.4 Standard Word Patterns

Pattern Number	Pattern	Weight*	Pattern Number	Pattern	Weight*
0	0000 0000	1	22	1010 1010	2
1	1000 0000	8	23	1111 1000	8
2	1100 0000	8	24	1111 0100	8
3	1010 0000	8	25	1111 0010	8
4	1001 0000	8	26	1110 1100	8
5	1000 1000	4	27	1110 1010	8
6	1110 0000	8	28	1110 0110	8
7	1101 0000	8	29	1101 1010	8
8	1100 1000	8	30	1111 1100	8
9	1100 0100	8	31	1111 1010	8
10	1100 0010	8	32	1111 0110	8
11	1010 1000	8	33	1110 1110	4
12	1010 0100	8	34	1111 1110	8
13	1111 0000	8	35	1111 1111	1
14	1110 1000	8	36		
15	1110 0100	8	|	Optional	
16	1110 0100	8	|	Patterns	
17	1101 1000	8	|		
18	1101 0100	8	97		
19	1101 0010	8	98	100	Restore
20	1100 1100	4	99	10000	Loopback
21	1100 1010	8			

*Probability - Weight/225
Bell PUB 62411

2.0 OPERATION AND APPLICATIONS

WARNING:

TO PREVENT ELECTRIC SHOCK, ALL "LINE" CONNECTIONS MUST BE MADE TO THE 2730 FIRST

1. **LEVEL MEASUREMENTS:** The output of a T1 Line with an "all one's" signal is inserted into the "RCV LINE" Jack and the "273 INPUT" Jack is plugged into the "INPUT" Jack of the 273. The level of the "all ones" signal is measured and displayed on a three digit display--range; -40.0 to +20.0 dBm. NOTE: The all 1's LED on the 273 should illuminate to confirm the correct all 1's signal for valid level measurements.

   The WORD Switch should be in the OFF position.

2. **CURRENT MEASUREMENTS:** The current in the Span Line constant supply power Loop is displayed on the "LEVEL/CURRENT" meter when the pushbutton "mA" is depressed. Current below 20 mA will cause the display to blink "-888".

3. **COUNTER MEASUREMENTS:**

The Errors output of the 273 is connected to the "ERRORS IN" BNC connector of the 2730 counter. The counter will tabulate all single bit errors, logical or Bipolar Violation, simultaneous with the 273 tabulation of error seconds.

4. **WORD GENERATOR:**

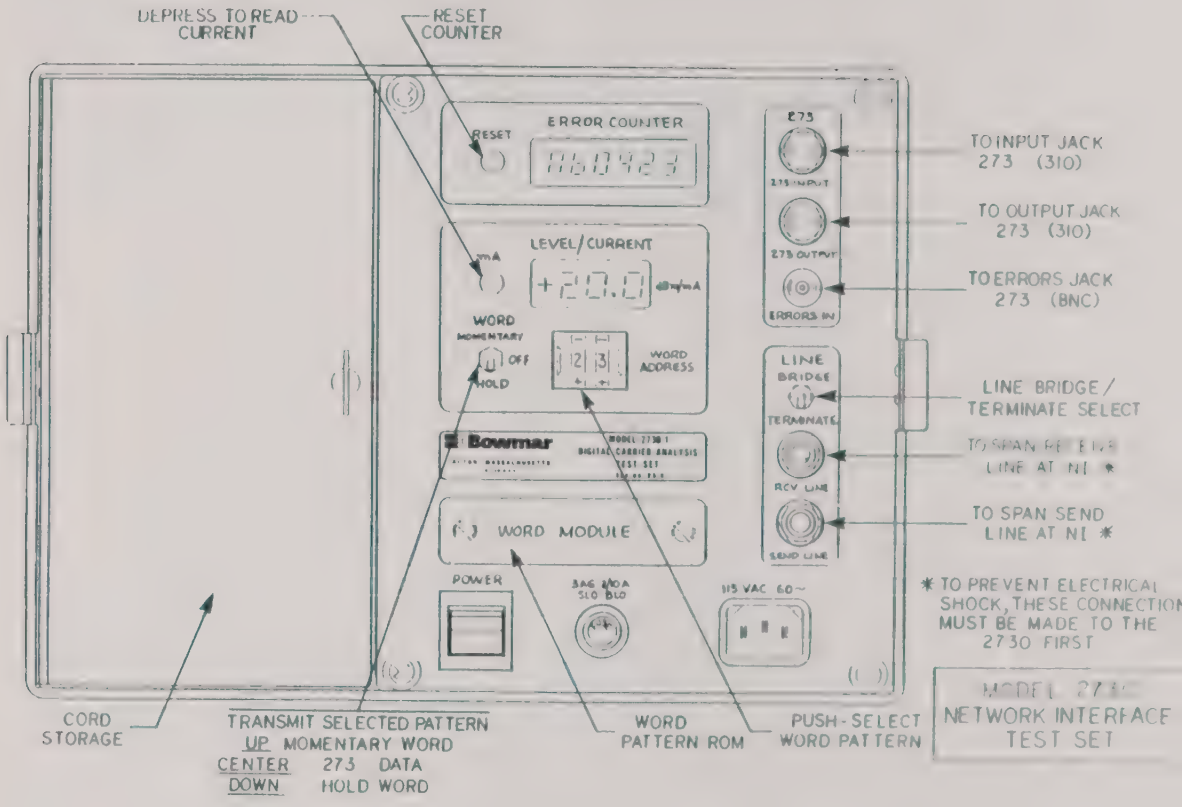
An output of the 273 is plugged into the "273 OUTPUT" Jack of the 2730 and the "SEND LINE" Jack of the 2730 is connected to the line undergoing test. The address selector is set for the appropriate address. Upon depressing the "WORD" Switch to "MOMENTARY", the 2730 will interrupt the QRSS pattern being passed from the 273 to the Line via the 2730 and send the selected pattern from the word generator for as long as the switch is held in the "MOMENTARY" position. Upon release, the output of the 2730 will return to the QRSS pattern provided by the 273.

A total of 100 codes may be selected from the EPROM mounted on the Program Module. The 2730, as furnished, will be loaded with the standard Loopback code "1 0 0 0 0", Restore code "100"

plus 36 stress pattern codes. The EPROM may be programmed with customer furnished addressable loopback codes as they are required.

5. With the 273 set to APS, the combination 273/2730 may be operated with CSU Looping back signals from the C.O. for Span Line Error Testing.

2.1 Front Panel Diagram



3.0 THEORY OF OPERATION

3.1 General

Refer to the Block Diagram, Figure 3.1 and the schematics in Section 5 to correlate the descriptions in this section.

3.2 dBm Meter

The line signal to be measured is plugged into J1 where it is terminated into 10K ohms (Bridge) or 100 ohm (terminate) depending on the setting of S1. This same signal is also coupled to J2 where it will then be connected to the 273's input. ONLY when the 273 is indicating an all ALL ONE's pattern will the level measurement indicated on the 2730 be valid.

The line signal to be measured is applied through R63 to a sharp bandpass filter consisting of C44 and L3. They are tuned by C43 to pass only a narrow band of frequencies centered around 772 kHz.

The peak amplitude of the bandpassed signal is detected by U18 and appears as a D.C. voltage at the junction of R66 and R59. This voltage is smoothed out by R59 and C45 and is buffered by U17. The voltage is again filtered by R36 and C28 and then applied to the D.C. to Log converter: U14.

The D.C. to Log converter, U14, then takes its input, which is actually a D.C. voltage equal to the peak of the line signal being measured, and converts it to a log current at Pin 14. This current will increase by an equal amount every time the input voltage doubles. For instance, if the input voltage goes from 2 to 4 to 8 volts, the log current will go from 1 to 2 to 3 mA. This is a logarithmic transfer function and since decibels are logarithmic in nature, the signal that comes out of the current to voltage converter (U15 Pin 1) can be used to express the level of the input signal in decibels. This logarithmic representation of Line signal's level is applied to the A-D converter, U1.

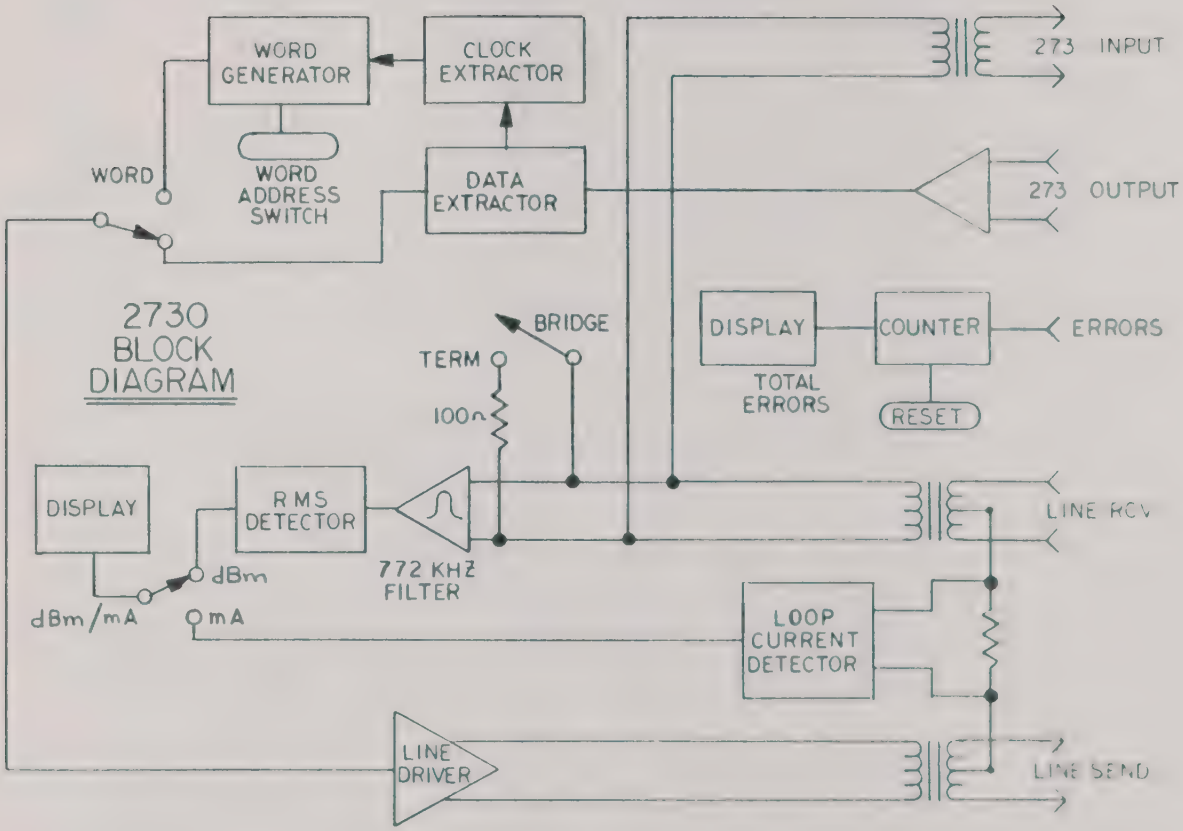

2730
BLOCK
DIAGRAM
WORD
GENERATOR
CLOCK
EXTRACTOR
WORD
ADDRESS
SWITCH
DATA
EXTRACTOR
WORD
273 INPUT
273 OUTPUT
BRIDGE
TERM
100Ω
DISPLAY
COUNTER
ERRORS
TOTAL
ERRORS
RESET
DISPLAY
RMS
DETECTOR
772 KHZ
FILTER
LINE RCV
dBm
dBm/mA
mA
LOOP
CURRENT
DETECTOR
LINE
DRIVER
LINE SEND

FIGURE 3.1

3.3 **A-D Converter**

U1 is an A-D converter which takes its input voltage on Pin 31 and displays this voltage on four 7-segment displays: DS1-DS4

3.4 **mA Meter**

The repeater loop current is measured by forcing it to flow through a resistance - R19/R20, thereby developing a voltage that is proportional to the amount of current flowing. The voltage across R19/R20, depending on its polarity, will turn on one of the LEDs in opto isolator U13. The LED will turn on one of the photo transistors thereby forcing a current through R30 which develops a voltage that is proportional to the current being measured. This voltage has its amplitude adjusted and is level shifted by U16. The output of U16 is fed to the A-D converter (U1) when the dBm/mA pushbutton is depressed.

U16, Pins 5 and 6 are used to detect current levels which are below a threshold of about 20 mA. This will cause U16's output, Pin 7, to go high. This voltage is fed to the display board where it is used to turn on Q3 thereby enabling U2, which oscillates at about 2 Hz, to drive U1, Pin 37 on and off. This causes a flashing 8's condition on the display. U2 will only oscillate when in the "mA" mode due to the arrangement of Q2 and S2.

3.5 **Data Extractor**

The Bipolar data signal from the 273's output is applied to J4. It is then buffered by differential amplifier U4. The output of U4 is applied to positive and negative peak detectors U3 and U9 respectively.

The Bipolar data signal is also applied to comparators U7 and U8. U7 has a reference equal to half the negative peak voltage of the data signal. Whenever the data signal exceeds this negative reference, the comparator's output goes high.

U8 has a reference equal to half the positive peak voltage of the data signal. Whenever the data signal exceeds this positive reference, the comparator's output also goes high.

The outputs of U7 and U8 are connected together (OR'd). This creates a Unipolar signal that goes high every time the Bipolar signal makes either a positive or negative excursion regardless of its amplitude.

This Unipolar data signal is strobed into flip-flop U1, Pin 1, and the data that appears at the Q output is actually the original encoded data before it was converted to the bipolar format for transmission by the 273.

3.6 **Clock Extractor**

The Unipolar data signal present at U2 Pin 11, is applied to a parallel resonant tank circuit consisting of C23 and L2. This tank circuit is adjusted by C24 to resonate (ring) at a frequency of 1.5440 MHz. Due to the high Q (efficiency) of this tuned circuit, it will continue to "ring" at its resonant frequency even though it may only be "pulsed" occasionally by the data transitions. The sinusoidal ringing voltage that appears across the tank circuit is fed into comparator U12. The output of comparator U12 is a 5 volt square wave that is representative of the sine wave voltage across the tank. This is the regenerated T1 clock (1.544 MHz).

3.7 **Word Generator**

The 2730 has the capability to either simply retransmit the QRSS data received from the 273 or to transmit any one of a hundred special patterns which may be used for a multitude of test applications. The patterns are stored in U1 - the Read Only Memory, which is contained on the Word Module board. The data that is stored in the ROM is retrieved by setting the push wheel switches, S5 and S6, to the appropriate number. These switches place a unique address on the eight high order address bits of the ROM. The remaining four lower order bits are sequentially cycled by binary counter U10, whenever the 2730 is in the WORD mode. The retrieved data comes out of Pin 9 of the ROM. Pin 10 is used to short cycle the counter at a rate equal to the word length, thereby repeating the word over and over again, until the 2730 is taken out of the WORD mode.

As mentioned previously in this section, the 2730 can either retransmit the data it received from the 273 or it can transmit one of its own stored words. These two modes are selected by S3, which is on the display board. S3 is debounced by R21-R23, C19 and U11. The output of U11, Pin 14, is inverted by the second section of U11 and is then applied to the "select" input of the third section of U11. The output of this third section of U11, Pin 4, will either be 273 data or WORD data, as selected by the

WORD switch - S3. From there it is sent to the output circuitry for transmission from the SEND jack.

3.8 Transmitter

The Unipolar data signal is sent to flip-flop U6, Pin 2, for restrobing by CLOCK, which was inverted by U6, Pin 10. The restrobed data is then fed to nand gate U2 along with CLOCK. The output of U2, Pin 3, will contain undesirable glitches which are caused by normal gate delays. These are integrated out by R4 and U2 Pins 4 and 5. The deglitched output of U2, Pin 6, is used to toggle flip-flop U1. The output of U2, Pin 6, is also fed to the two commonly connected AND gate inputs of Line Driver U5. The other two inputs are driven from the complementary toggling outputs of U1, Pins 9 and 8 - thereby alternately enabling either the top AND gate in U5 or the bottom gate.

The two AND gate outputs are used to drive their associated transistors. The top transistor is connected so as to cause a current to flow upwardly through output transformer, T1, and the bottom transistor is connected so as to force current to flow in the opposite direction. Only one transistor will be on at a time as determined by the toggling outputs of flip-flop U1. The current flow thrcugh transformer T1 is from the primary center tap through either half of the primary to ground through one of the transistors.

The primary center tap is connected to a high current voltage source consisting of U17 and Q2. This "alternation" of current flow through T1's primary will cause both a positive and a negative voltage to be induced into T1's secondary - thereby creating the Bipolar data signal which is transmitted from SEND jack J3 out onto the line.

3.9 Error Counter

Errors to be counted are routed to Counter/Display Driver U3 which is located on the Display Board. U3 is a fully integrated seven decade counter-decoder-driver chip. It is reset by applying a ground through S4 to Pin 14.

4.0 CALIBRATION PROCEDURES

4.1 Test Equipment Requirements

EQUIPMENT TYPE	REQUIRED CHARACTERISTICS
a. Oscilloscope	Dual Trace, 100 MHz
b. Digital Multimeter	3 1/2 Digit, D.C. Current $\geq$ 300 mA
c. Signal Generator	1 MHz, sine wave @ 0 to 4 Vrms output
d. High Frequency DVM	3 1/2 Digit, RMS Reading, 10 MHz frequency response
e. D.C. Power Supply	0 to 40 Volt @ 250 mA
f. Frequency Counter	10 MHz frequency response
g. Test Transmitter	Bowmar/ALI D271-129
h. mA Adjustment Plugs	See Figure 4.1

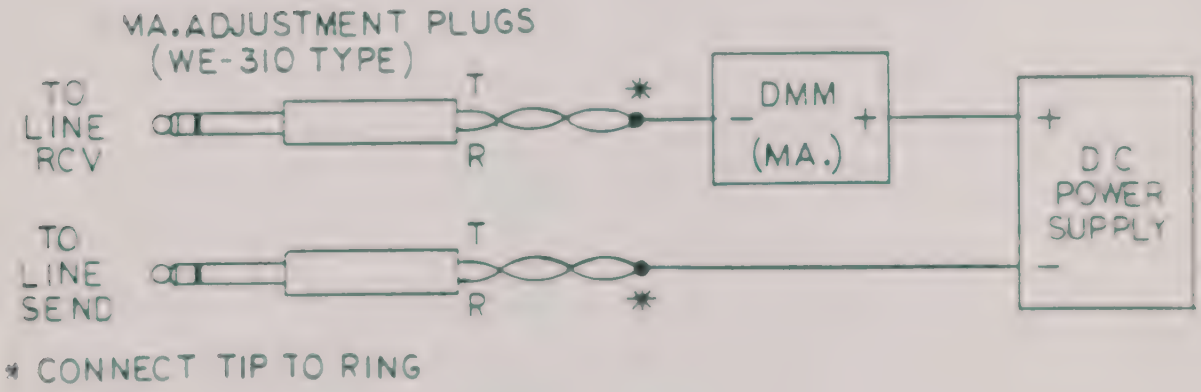


FIGURE 4.1

4.2 dBm Calibration

Equipment Required

a. Signal Generator
b. High Frequency DVM
c. Frequency Counter

1. Connect Signal Generator to the (balanced) input of the RCV LINE jack on the 2730.

2. Set Signal Generator to SINE WAVE output.

3. Using Frequency Counter, adjust the Signal Generator's output frequency to EXACTLY 772.00 kHz.

4. Using High Frequency DVM, adjust the signal generator's output amplitude for .316 volts rms. Generator MUST be connected to 2730 as stated above.

5. Set WORD switch on 2730 to OFF.

6. Adjust C43 for maximum POSITIVE reading.

7. Adjust R32 for a reading of 00.0 dBm.

8. Adjust signal generator's output for 3.16 volts rms.

9. Adjust R34 for a reading of +20.0 dBm.

10. Adjust signal generator's output for 3.16 mVrms.

11. Adjust R37 for a reading of -40.0 dBm.

12. Repeat Steps 4 through 11 until no further adjustments are required.

4.3 **ma. Calibration**

EQUIPMENT REQUIRED

a. Digital Multimeter (DMM) b. D.C. Power Supply
c. ma. Adjustment Plugs

1. Connect above equipment as shown in Figure 4.1.

2. Set Digital Multimeter to read $\geq$ 200 ma. D.C.

3. Adjust D.C. power supply for a current flow of 200 ma. as shown on DMM.

4. Push and hold "ma." switch on the 2730.

5. Adjust R52 for a reading of "210 ma."

6. Adjust D.C. Power Supply for a current flow of 30 ma. as shown on DMM.

7. Push and Hold "ma." switch on the 2730.

8. Adjust R51 for a reading of "32 ma" on the 2730.

9. Repeat Steps 3 through 8 until no further adjustments are necessary.

10. Adjust D.C. Power Supply for a reading of "100 ma" on the 2730.

11. Reverse the connections to the D.C. Power Supply.

12. Push and hold "ma." switch.

13. Adjust R50 for a reading of "100 ma."

4.4 Clock Calibration

EQUIPMENT REQUIRED

a. Frequency Counter
b. Oscilloscope
c. Test Transmitter

1. Connect FREQUENCY COUNTER to U2, Pin 8.

2. Connect Oscilloscope, Channel 1, to U2, Pin 8.

3. Connect Oscilloscope, Channel 2, to U2, Pin 11.

4. Set Oscilloscope to SYNC on CHAN. 1.

5. Connect TEST TRANSMITTER to "273 OUTPUT" jack on 2730.

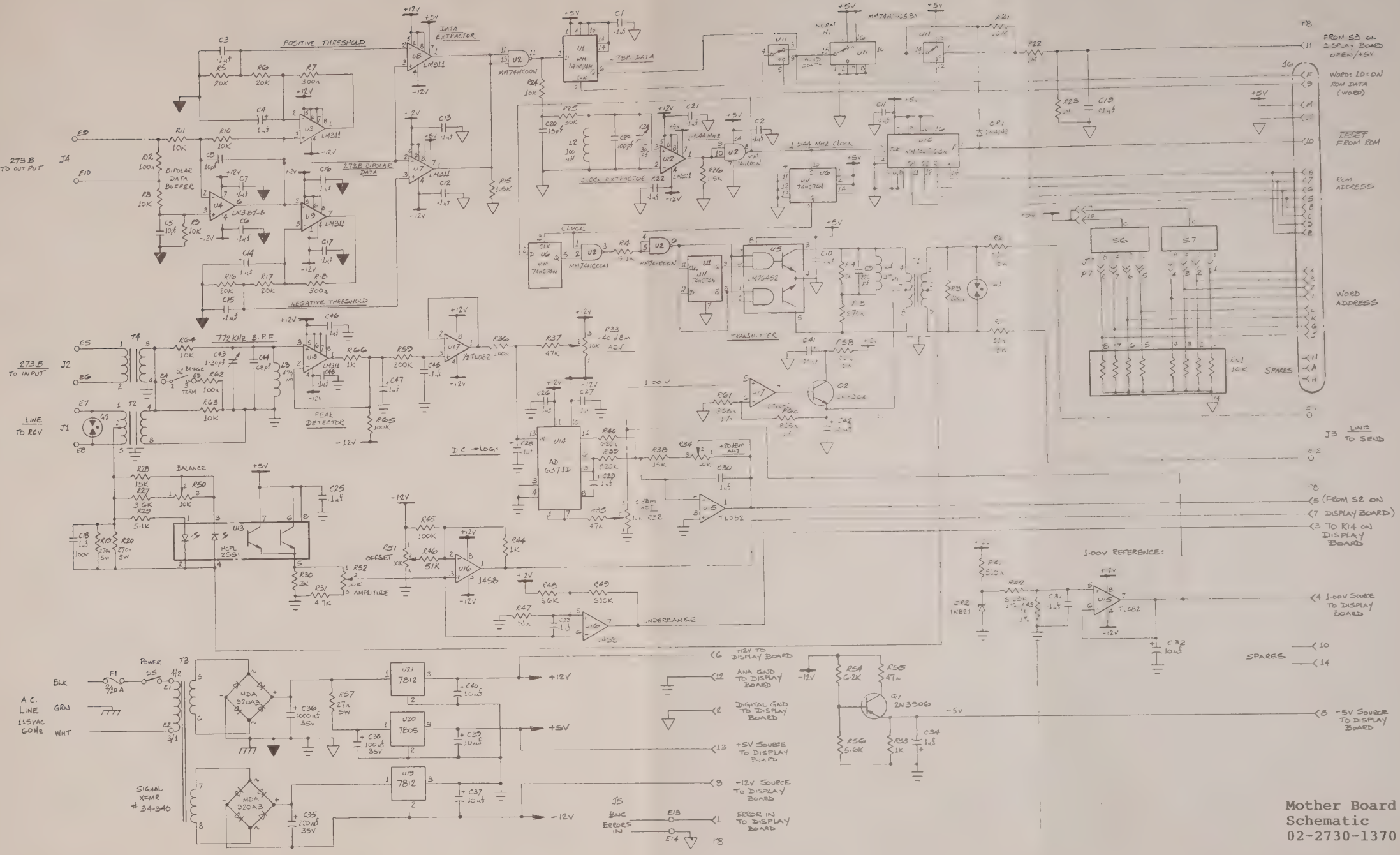
6. Set Test Transmitter to deliver a 1 and seventeen 0's T1 pattern.

7. Adjust C24 for a reading of 1.5440 MHz on FREQUENCY COUNTER.

8. Re-adjust C24 until the RISING edge of the clock (Chan. 1) occurs slightly to the right of the center of the POSITIVE side of the DATA signal (Chan. 2).

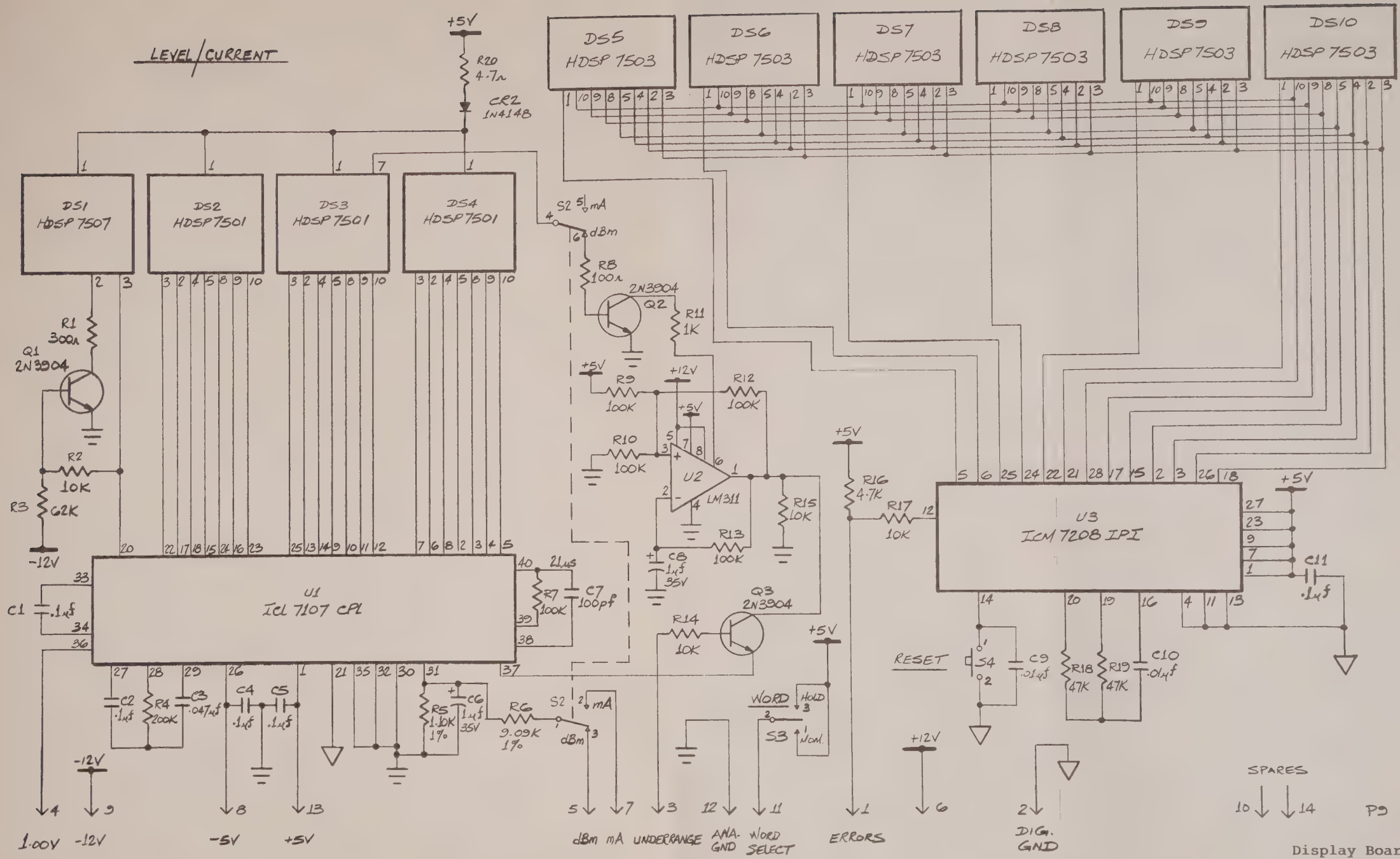
5.0 DRAWINGS

FIGURE 1:	Mother Board Schematic	02-2730-1370/B
FIGURE 2:	Display Board Schematic	02-2730-1350/B
FIGURE 3:	Word Generator Board Schematic	02-2730-1360/A
FIGURE 4:	Interconnection Diagram	02-2730-1380/B



Mother Board Schematic
02-2730-1370

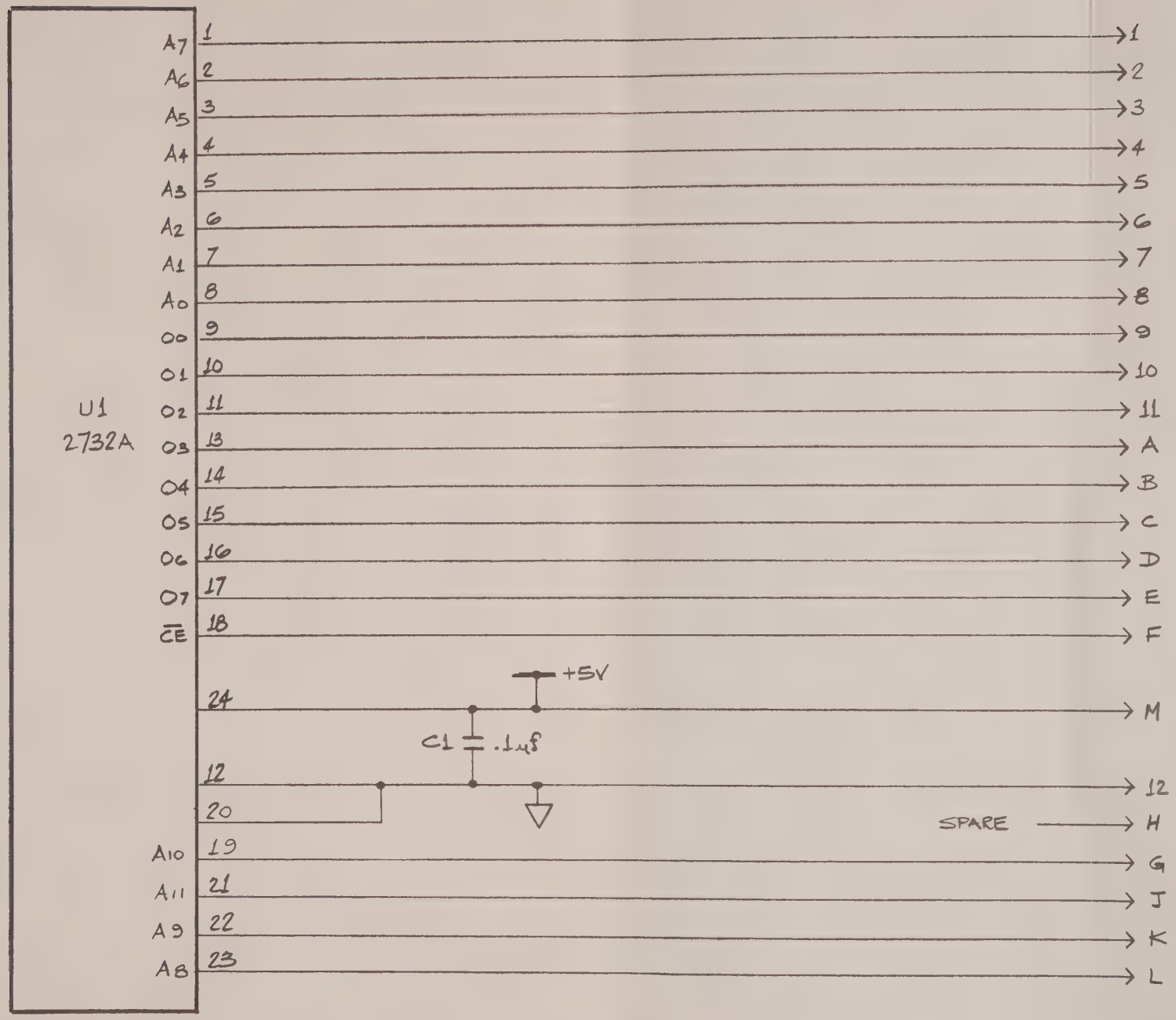
FIGURE 1



Display Board
Schematic
02-2730-1350

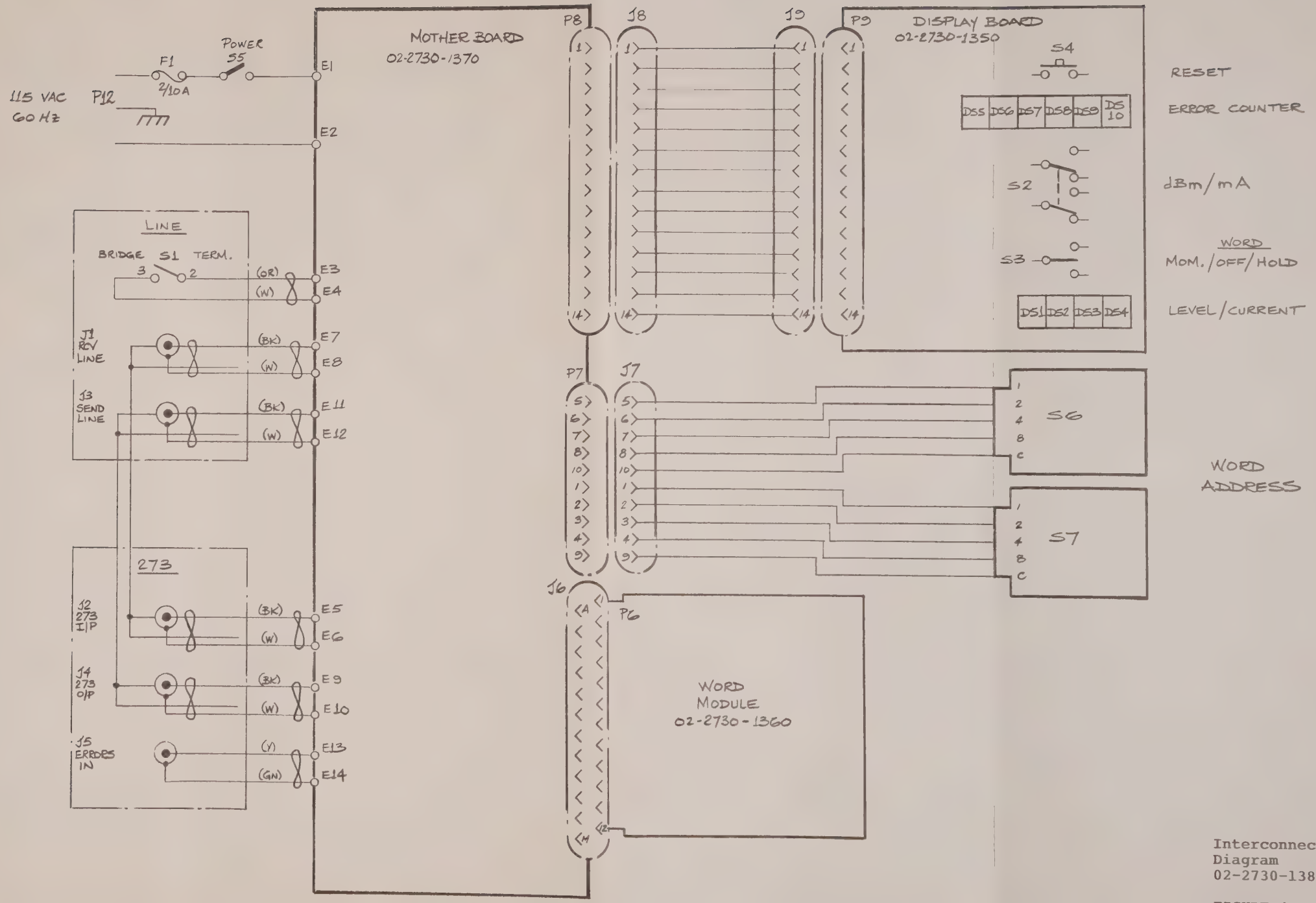
FIGURE 2

P6



Word Generator Board
Schematic
02-2730-1360

FIGURE 3



Interconnection
Diagram
02-2730-1380

FIGURE 4

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	MANUFACTURER'S PART NUMBER	BOWMAR/ALI'S PART NUMBER
DISPLAY BOARD ASSEMBLY - 02-2730-2350				
C6, 8	Capacitor, 1.00µf, 35V, 10%	Sprague	196D105X9035JA1	11-0400-0039
C3	Capacitor, .047µf, 50V, 10%	Centralab	CW20C473K	11-0600-0042
C9-10	Capacitor, 0.01µf, 50V, 80,-20%	Unitrode	CGC103ZDZ	80-11-0600-0032
C1-2,4-5,11	Capacitor, 0.10µf, 50V, 80,-20%	Unitrode	CGD104ZDZ	80-11-0600-0036
C7	Capacitor, 100pf, 500V, 5%		CM04FD101J03	11-0300-0051
CR1	Diode, 0.2A		1N4148	20-0009-0000
DS1-[illegible]	Display, LED, Red, 7-Segment	Hewlett Packard	HDSP-7503	14-0030-0000
DS2-4	Display, LED, Red, 7-Segment	Hewlett Packard	HDSP-7501	14-0052-0000
DS1	Display, LED, Red, Overflow	Hewlett Packard	HDSP-7507	14-0053-0000
P1	Connector, Flat, 14 Pin	Ansley	609-1427	34-0200-0015
Q1-3	Transistor, Low Power, NPN		2N3904	21-0003-0000
R11	Resistor, 1.00K, 5%		RCR07G102JS	10-1201-1003
R5	Resistor, 1.10K, 1%		RN55C1101F	10-0201-1103
R7,14-15,17	Resistor, 10.0K, 5%		RCR07G103JS	10-1201-1004
R8	Resistor, 100 ohm, 5%		RCR07G101JS	10-1201-1001
R7,9-10,12-13	Resistor, 100K, 5%		RCR07G104JS	10-1201-1005
R4	Resistor, 200K, 5%		RCR07G[illegible]JS	10-1201-2005
R1	Resistor, 300 ohm, 5%		RCR07G301JS	10-1201-3002
R10	Resistor, 4.7 ohm, 5%		RCR[illegible]	10-1006-4700
R16	Resistor, 4.7K, 5%		RCR07G472JS	10-1201-4703
R18-19	Resistor, 47.0K, 5%		RCR07G473JS	10-1201-4704
R2	Resistor, 62.0K, 5%		RCR07G623JS	10-1201-6204
R9	Resistor, 9.09K, 1%		RN55C9091F	10-0201-9093
S1	Switch, DPDT-MOM, Pushbutton	C&K Components	8221-S-D9-V30-GE	31-0077-0000
S4	Switch, SPDT-MOM, Pushbutton	C&K Components	8121-S-D9-V30-GE	31-0076-0000
S3	Switch, SPDT, Toggle	C&K Components	7107-SP-D9-V30-GE	31-0075-0000
U1	Integrated Circuit, A/D	Intersil	ICL7107CPL	22-0113-0000
U4	Integrated Circuit, DEC-CNTR	Intersil	ICM7208IPI	23-1400-1801
U3	Integrated Circuit, COMPARE	National	LM311N	80-22-0073-0000

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	MANUFACTURER'S PART NUMBER	BOWMAR/ALI'S PART NUMBER
WORD GENERATOR BOARD ASSEMBLY - 02-2730-2360				
C1	Capacitor, 0.10µf, 50V, 80,-20%	Unitrode	CGD104ZDZ	80-11-0600-0036
U1	Integrated Circuit, EPROM	Intel	D2732A-4	24-0000-0006
MOTHER BOARD ASSEMBLY - 02-2730-2370				
C4,14,28-29, C34,47	Capacitor, 1.00µf, 35V, 10%	Sprague	196D105X9035JA1	11-0400-0039
C32,37,39-42	Capacitor, 10.0µf, 25V, 10%	Sprague	196D106X9025KA1	11-0400-0022
C19	Capacitor, 0.01µf, 50V, -20/80%	Unitrode	CGC103ZDZ	11-0600-0032
C1-3,6-7,10-13, C15-18,21-22, C25-27,30-31, C33,45-46,48	Capacitor, 0.10µf, 50V, -20/80%	Unitrode	CGD104ZDZ	11-0600-0036
C5,8	Capacitor, 10.0pf, 500V, 5%		CM04CD100D03	11-0300-0009
C23	Capacitor, 100pf, 500V, 5%		CM04FD101J03	11-0300-0051
C20	Capacitor, 15.0pf, 500V, 5%		CM04CD150J03	11-0300-0000
C9	Capacitor, 220pf, 500V, 5%		CM04FD221J03	11-0300-0004
C44	Capacitor, 68.0pf, 500V, 5%		CM04ED680J03	11-0300-0080
C24, 43	Capacitor, 1-30pf, 250V	Voltronics	SP-30	11-0100-0011
C38	Capacitor, 100µf, 35V, 20%	Nichicon	TLB1V101M	11-0500-0108
C36	Capacitor, 1000µf, 35V, 20%	Nichicon	TLB1V102M	11-0500-0110
C35	Capacitor, 220µf, 35V	Nichicon	TLB1V221M	11-0500-0109
CR2	Diode, 6.2V, 5%		IN821	20-0069-0000
CR1	Diode, 0.2A		1N4148	20-0009-0000
E1-14	Terminal	Cambion	160-2027-02-01-00	34-1400-0002
G1-2	Transient Suppressor	Clare	CG90L	15-0000-0001
J6	Connector, 24 Pos.	Amp	1-583715-0	34-0300-0085
L2	Inductor, 100µh, 10%	Cambion	553-3635-25-02-00	12-0035-0000
L3	Inductor, 470µh, 10%	Cambion	553-3635-33-02-00	12-0036-0000
L1	Inductor, 47µh, 10%	Cambion	553-3635-21-02-00	12-0037-0000

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	MANUFACTURER'S PART NUMBER	BOWMAR/ALI'S PART NUMBER
MOTHER BOARD - 02-2730-2370 (Con't)				
P8	Connector, 14 Pin	Ansley	609-1427ES	34-0200-0002
P7	Connector, 10 Pos.	Amp	1-640383-0	34-0300-0083
Q2	Transistor, Low Power, NPN		2N3904	21-0003-0000
Q1	Transistor, Low Power, PNP		2N3906	21-0004-0000
R32-34,50-52	Resistor, 10K, 15T	Beckman Inst.	89PR10K	80-10-0100-0043
R43	Resistor, 1K, 1%		RN55C1001F	10-0201-1003
R14,44,53,66	Resistor, 1K, 5%		RCR07G102JS	10-1201-1003
R22-23	Resistor, 1M, 5%		RCR07G105JS	10-1201-1006
R15,26	Resistor, 1.5K, 5%		RCR07G152JS	10-1201-1503
R8-11,24,63,64	Resistor, 10K, 5%		RCR07G103JS	10-1201-1003
R21	Resistor, 10M, 5%		RCR07G106JS	10-1201-1007
R12,36,62	Resistor, 100 ohm, 5%		RCR07G101JS	10-1201-1002
R58	Resistor, 100 ohm, 5%		RCR20G101JS	10-1202-1002
R45,65	Resistor, 100K, 5%		RCR07G104JS	10-1201-1005
R28,38	Resistor, 15K, 5%		RCR07G153JS	10-1201-1504
R5-6,16-17	Resistor, 20K, 5%		RCR07G203JS	10-1201-2004
R3	Resistor, 200 ohm, 5%		RCR07G201JS	10-1201-2002
R59	Resistor, 200K, 5%		RCR07G204JS	10-1201-2005
R13	Resistor, 270 ohm, 5%		RCR07G271JS	10-1201-2702
R30	Resistor, 3K, 5%		RCR07G302JS	10-1201-3003
R27	Resistor, 3.6K, 5%		RCR07G362JS	10-1201-3603
R25	Resistor, 30K, 5%		RCR07G303JS	10-1201-3004
R7,18	Resistor, 300 ohm, 5%		RCR07G301JS	10-1201-3002
R61	Resistor, 365 ohm, 1%		RN55C3650F	10-0201-3652
R31	Resistor, 4.7K, 5%		RCR07G472JS	10-1201-4703
R55	Resistor, 47 ohm, 5%		RCR07G470JS	10-1201-4701
R48,49	Resistor, 47K, 5%		RCR07G473JS	10-1201-4704
R4,29	Resistor, 5.1K, 5%		RCR07G512JS	10-1201-5103
R42	Resistor, 5.23K, 1%		RN55C5231F	10-0201-5233
R56	Resistor, 5.6K, 5%		RCR07G562JS	10-1201-5603
R1-2	Resistor, 51 ohm, 5%		RCR20G5101JS	10-1202-5101
R47	Resistor, 51 ohm, 5%		RCR07G510JS	10-1201-5101

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	MANUFACTURER'S PART NUMBER	BOWMAR/ALI'S PART NUMBER
MOTHER BOARD - 02-2730-2370 (Con't)				
R46	Resistor, 51K, 5%		RCR07G513JS	10-1201-5104
R41	Resistor, 510 ohm, 5%		RCR07G511JS	10-1201-5102
R49	Resistor, 510K, 5%		RCR07G514JS	10-1201-5105
R48	Resistor, 56K, 5%		RCR07G563JS	10-1201-5604
R54	Resistor, 6.2K, 5%		RCR07G622JS	10-1201-6203
R40	Resistor, 620 ohm, 5%		RCR07G621JS	10-1201-6202
R39	Resistor, 820K, 5%		RCR07G824JS	10-1201-8205
R60	Resistor, 825 ohm, 1%		RN55C8250F	10-0201-8252
R19-20	Resistor, 270 ohm, 5%	Clarostat	VC5E-270 Ohm	10-0000-0067
R57	Resistor, 27 ohm, 5%	Clarostat	VC5E-27 Ohm	10-0000-0066
RN1	Resistor Network	Beckman Inst.	898-1-R10K	22-0077-0000
T1-2	Transformer, Wideband	Bowmar/ALI	09-0130-6494	09-0130-6494
T3	Transformer, Power, 110V	Signal Trans.	LP34-340	13-0024-0000
T4	Transformer, Pulse, 1:1:1	Pulse Eng.	PE5763	13-0003-0000
U14	Integrated Circuit, RMS-DC	Analog Devices	AD637JD	22-0149-0000
U13	Integrated Circuit, OPTO-CPL	Hewlett Packard	HCPL-2531	22-0164-0000
U3,7-9,12,18	Integrated Circuit, COMPARE	National	LM311N	22-0073-0000
U16	Integrated Circuit, OP-AMP	National	LM1458N	22-0048-0000
U4	Integrated Circuit, OP-AMP	National	LM318N	80-22-0152-0000
U20	Integrated Circuit, VOLT REG.	National	LM7805CT	22-0160-0000
U11	Integrated Circuit, ANALOG SW.	National	MM74HC4053N	23-1601-1012
U2	Integrated Circuit, 4-NAND	Texas Inst.	SN74HC00N	80-23-1600-0600
U10	Integrated Circuit, BIN-CNTR	Texas Inst.	SN74HC163N	80-23-1600-0650
U1,6	Integrated Circuit, D-FLOP	Texas Inst.	SN74HC74N	80-23-1600-0620
U5	Integrated Circuit, DRIVER	Texas Inst.	SN75452BP	80-22-0011-0000
U15,17	Integrated Circuit, OP-AMP	Texas Inst.	TL082CP	80-22-0150-0000
U19,21	Integrated Circuit, VOLT-REG	Fairchild	UA7812UC	22-0166-0000
VR1-2	Diode, BRIDGE NET	Notorola	MDA920A3	20-0062-0000

REF. DES.	COMPONENT DESCRIPTION	COMPONENT MANUFACTURER	MANUFACTURER'S PART NUMBER	BOWMAR/ALI'S PART NUMBER
COVER ASSEMBLY - 02-2730-2400				
P12	Connector, 3 Pin	Switchcraft	EAC-302	34-0300-0008
F1	Fuse-Holder	Littlefuse	342001A	15-0500-0009
S5	Switch, SPDT, Rocker	C&K Components	5101ZQE	31-0020-0000
CABLE ASSEMBLY: PUSHWHEEL - 02-2730-2420				
J7	Connector, 10 Pos.	Amp	1-640250-0	34-0300-0084
S6-7	Switch, BCD Pushwheel	Cherry	T57-02-M2	31-0080-0000
CABLE ASSEMBLY: DISPLAY BOARD - 02-2730-2430				
J8-9	Connector, 14 Pin	Ansley	609-1441	34-0200-0001
CABLE ASSEMBLY: RCV LINE/273 INPUT - 02-2730-2440				
J1-2	Connector, 3 Pin	Switchcraft	MN-112B	34-0400-0043
CABLE ASSEMBLY: SEND LINE/273 OUTPUT - 02-2730-2450				
J3-4	Connector, 3 Pin	Switchcraft	MN-112B	34-0400-0043
CABLE ASSEMBLY: ERROR IN - 02-2730-2460				
J5	Connector, 1 Pin	Amphenol	UG31-010	34-0400-0010
CABLE ASSEMBLY: BRIDGE/TERM. SWITCH - 02-2730-2470				
S1	Switch, SPDT, Toggle	C&K Components	7101-SP-D-ZQE	31-0079-0000

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